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WASPS, insects of the order Hymenoptera, most typically characterized by a narrow waist connecting the thorax and the abdomen. Ants, bees, sawflies, horntails, and a few others are also Hymenoptera. The remaining families of the order are known loosely as wasps, although the average observer would not think of them as wasps. They are often called flies, but this is a misnomer, as true flies of the order Diptera have only one pair of wings, while Hymenoptera have two pairs. These atypical wasps are mostly parasites and are extremely important in maintaining the balance of nature by destroying the plant-feeding insects which compete with man for food.

Parasitic Wasps.—The parasitic wasps include the ichneumons, braconids, proctotrupids, and chalcidoids and range from large species whose larvae feed internally on the bodies of caterpillars and other insects to minute forms whose entire growth can occur within an egg of a small insect. These minute wasps are among the smallest insects, some of them being only 0.21 millimeters (less than one hundredth of an inch) in length.

The majority of the parasitic wasps insert their eggs into the bodies of their living and active hosts by means of sharp ovipositors. The host insect continues its normal life until killed by the growing wasp larva or grub within. Most such wasps do not use their ovipositors as stings to defend themselves. A few, however, temporarily inactivate their hosts by means of a poison injected through the ovipositor. Such wasps may also sting in defense if picked up in the fingers. In more typical wasps the ovipositor has lost its original egg-laying function and serves only as a sting. The eggs are too large to pass through the sting and are laid from an aperture at its base. As the sting is a modified ovipositor, it is absent in all male Hymenoptera.

Typical Wasps.—It is an easily understood step from stinging parasitic wasps to certain more typical wasps such as Scoliidae which search for their prey, usually white grubs—larvae of June beetles (Scarabaeidae)—in the soil. Such a grub is paralyzed with a sting and an egg laid on it, after which the wasp goes on. Several of the natural enemies of the Japanese beetle, introduced from Japan in an attempt to control that pest, have such habits.

Nonsocial Wasps.—The next important step in wasp evolution appears to have been the establishment of a home, a nest, to which the wasp returns with its prey. (See Nests and Nest Building.) The wasps discussed above have no such home, but simply wander about in search of hosts or prey. Most typical wasps, however, construct a nest, then paralyze the prey with a sting and carry it to the nest. The wasp places the prey in a small enclosed space (cell), lays an egg, seals the cell, and goes on to construct and provision other cells. This manner of providing food for the young is called mass provisioning. Such mother wasps never see their own young, for the cells are sealed immediately after egg laying and the mother is dead before her progeny mature and emerge. The advantage of paralyzing rather than killing the prey stored in the nest seems to be that the growing wasp grubs have fresh, in fact living, food to eat.

Among the many wasps whose behavior is as described above are the tarantula hawk (*Pepsis*), blue-black with red wings, and large enough to overpower and paralyze tarantulas; the cicada killer (*Sphecius*), a giant yellow-banded wasp that captures and paralyzes cicadas or locusts; the thread-waisted sand wasps (*Ammophila*), which put paralyzed caterpillars in holes in the soil as food for their larvae; the familiar mud daubers (*Sceliphron*) which make their mud nests on walls; and tiny black wasps (*Stigmus*) which fill their cells in pithy stems with paralyzed aphids or plant lice.

Wasps such as the above are called solitary or nonsocial because each female makes her own nest and never lives with her progeny. Some wasps, however, have become subsocial, that is, the food is provided progressively as needed by the larva. Some eumenid wasps provide whole caterpillars progressively, others partly chewed caterpillars, and a few chew up caterpillars into masses of tissue.

Social Wasps.—The latter method of feeding is that used by the social wasps (family Vespidae). These wasps are termed social because the mother is sufficiently long-lived to live with her mature progeny. The resulting colony is held together partly by exchange of food; the adults feed the larvae but also crave a secretion of the larvae. This mutual exchange of food is called trophallaxis. In such a colony the mother is the queen, while her female progeny are mostly slightly smaller, do not lay eggs, and are called workers. Nests of social wasps are nearly all made of wasp paper. Such paper, made from wood and stem fibers, was made by wasps millions of years before man learned the art.

The common social wasps of temperate climates pass the winter as fertilized young queens hidden in protected places. In the spring they come forth and usually each builds a small nest to rear her first progeny, all of which are females and mature as workers. After they are mature the queen ceases foraging and spends her time in the nest, where she lays eggs while the workers do the foraging, enlarge the nest, and defend it. In late summer the queen's eggs, for reasons that are little understood, develop not into workers but into males and young queens. With cold weather all die except the young fertilized queens.

In North America there are two principal types of social wasps, each represented by numerous species. One type, the common paper wasps (*Polistes*), have small and usually timid colonies on exposed combs of paper cells hanging from eaves of buildings, branches of bushes or trees, and many similar localities. In fall the young fertilized queens often work into houses while searching for hibernating quarters. The other type constructs combs surrounded by paper envelopes. The colonies are much larger than in *Polistes*, and consist of hundreds or thousands of individuals having exceedingly painful stings. Those that nest in cavities in the soil (*Vespula*) are called yellow jackets while those that place their nests on branches of bushes or trees (*Dolichovespula*) may be called yellow jackets, although the larger species are often termed hornets. A single species introduced from Europe (*Vespa crabro*) nests in hollow trees and similar places and is called the European hornet.

Consult Wheeler, William M., *Social Life Among the Insects* (New York 1923); Michener, Charles D., and Michener, Mary H., *American Social Insects* (New York 1951); Richards, Owain W., *The Social Insects* (New York 1953).

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WASSAIL, wŏs''l (Anglo-Saxon *wes hāl*, be whole or have health), a greeting or toast on a special occasion, at the same time offering a beverage and drinking a health. In medieval times and earlier, a bowl was prepared with ale or wine, flavored with sugar, spices, toast, and fruit, like the modern punch, probably heated by plunging a redhot poker in the mixture. Groups of people went from house to house on Christmas and Twelfth Night, singing carols, and were offered the wassail bowl at each stop. This is the origin of the old English carol *Here we come a-wassailing . . .* In Shakespeare's *Hamlet*, Act I, scene 4, Hamlet says:

> The king doth wake tonight and takes his rouse,
> Keeps wassail . . .

An old poem of Robert de Brunne (13th century) describes the custom of offering the wassail bowl to a guest, with the proper response, "Drink hail." A wassail is sometimes used to denote a drinking song, and wassailers came to mean drunkards, as in John Milton's *Comus*.

WASSERMANN, väs'ẽr-män, **August von**, German bacteriologist: b. Bamberg, Bavaria, Feb. 21, 1866; d. Berlin, Germany, March 15, 1925. After studying at the universities of Munich, Erlangen, Strasbourg, and Vienna, Wassermann began practice as a physician in Strasbourg in 1888. Under Robert Koch (q.v.) he was director of the department of experimental therapy and biochemistry at the Koch Institute for Infectious Diseases, Berlin, and later was director at the Kaiser Wilhelm Institute in Berlin-Dahlem (1913). He developed antitoxin treatment of diphtheria, inoculation against typhoid, cholera, and tetanus, and did valuable work in pre-tuberculosis cases. He also worked out a differentiation classification for blood groups. His work in diagnosing syphilis is best known. Working with Albert Neisser and Carl Bruck on the Bordet-Gengou reaction, he discovered a complement-fixation test for syphilis, which is called by his name (1906).

Wassermann Reaction or Test.—A serum composed of an extract of the *Spirochaeta pallida* is used to test the presence in the blood or spinal fluid of antibodies which have been formed as the result of an infection of syphilis which affected tissue cells. This may be found even though evidence of the disease is not observable at the time. If the patient is syphilitic the complement in the serum will not dissolve the red blood cells; if syphilis is absent, the cells are dissolved, producing a clear fluid in the test tube. Sometimes a positive reaction is obtained from yaws, leprosy, malaria, and infectious mononucleosis. Also, a positive reaction may be had from the spinal fluid, and a negative from the blood. Nevertheless, the Wassermann test, even though simplified by later research, is still considered the most reliable, and in some states, the test is required for a premarital medical certificate.

WASSERMANN, Jakob, German-Jewish novelist: b. Fürth, Bavaria, March 10, 1873; d. Alt-Aussee, Austria, Jan. 1, 1934. Wassermann's early years were spent in extreme hardship, but after his stories and poems appeared in *Simplicissimus*, he went on to attain fame and recognition as one of the foremost German writers. In 1896 his novel *Die Juden von Zirndorf* (tr. as both *The Jews of Zirndorf* and *The Dark Pilgrimage*, 1933), introduced a writer of great narrative ability who employed strange characters and posed interesting problems. In 1898 he went to live in Austria. Among his novels were *Caspar Hauser* (1908; Eng. tr., 1928); *Das Gänsemännschen* (1915; Eng. tr., *The Goose Man*, 1922); *Christian Wahnschaffe* (1919; Eng. tr., *The World's Illusion*, 1920); *Der Fall Maurizius* (1928; Eng. tr., *The Maurizius Case*, 1929); *Etzel Andergast* (1931; Eng. tr., 1928); its sequel, *Joseph Kerkhoven's dritte Existenz* (1934; Eng. tr., *Kerkhoven's Third Existence*, 1934). His autobiography, *Mein Weg als Deutscher und Jude* (1921; Eng. tr., *My Life as German and Jew*, 1933), expressed the difficulties of the Jew in Europe even before the Nazi anti-Semitism.

Consult Blankenagel, John Carl, *Writings of Jakob Wassermann* (Boston 1942).

WASTE, *in law*, the result of any act or omission by the tenant of any particular estate by which it is rendered of less permanent value. Waste is of two sorts, *voluntary* and *permissive*. The former is that caused by active procedure on the part of the tenant, such as the destruction or alteration of buildings, the removal of fixtures, the cutting down of fruit or shade trees or ornamental shrubs, or in the case of a wood lot, the removal of timber trees and cordwood and their sale for the benefit of the tenant. The latter may, however, cut such timber as is needed and used in the repair of the buildings on the estate. Permissive waste is that caused by negligence, such as the allowing of buildings to fall out of repair. Under the law of waste a tenant may work any mine or quarry already in existence on the leased property unless specifically forbidden in the lease. But he is not permitted to open and operate for his own gain either mine or quarry. In some states of the United States the tenant is permitted to clear up wild land for agricultural purposes; but he must not sell the product of such clearing in cordwood or lumber for his own emolument. On the theory of permissive waste as developed at common law is based the rule which throws upon the tenant the responsibility of making all ordinary repairs in the premises which he occupies. Though he cannot strictly be required to make repairs, and is not liable in damages for any failure so to do, yet in case of an action for waste against him his only defense is a demonstration that he has repaired the waste, and he, therefore, prefers to maintain the premises in repair.

WASTE, or BY-PRODUCTS. Waste is that portion of raw material used in any specific manufacture which is in the process rendered useless for that particular line. However, the name is sometimes retained long after a substance, at one time of little or no value, has been utilized as raw material in some other industry. In every manufacturing process, mechanical or chemical, there is more or less left over material which becomes waste. The examples given below relate to new waste, but nearly everything we use wears or corrodes, or gets broken or unshapely, and so rags and rust and scraps arise. On the other hand, the rust which arises from corroding iron is utter waste, since it can never be profitably collected at all. There is a kind of waste, for the most part difficult to prevent, which goes on in the consumption of fuel, and in certain processes of roasting or calcination in the smelting of metals. Roundly speaking, the best designed steam-engines and boilers require only half as much coal per horse power per hour as those less skilfully constructed, and the fuel unnecessarily consumed by bad boiler furnaces is largely wasted as smoke through imperfect combustion. The utilization of blast furnaces gases for heating purposes, and the recovery of tar and ammonia also produced at the same time from the coal consumed in these furnaces, form an instance of a double saving from the same source. In the report of the chief inspector of alkali works for 1891, it is stated that the plant put up in recent years for collecting tar, ammonia, etc., at 57 Scotch blast furnaces cost $2,223,000, a sum fully equal to the cost of building the furnaces themselves. The condensing flues, miles in length, connected with some lead-smelting furnaces are modern examples for appliances to condense lead fumes or vapor which formerly was allowed to escape, causing much loss of the metal.

Some instances of how waste in a solid form arises in working rock and other mineral substances may now be given. In shaping and dressing granite paving stones as much as three-fourths of the rock quarried is, in some instances at least, wasted. This waste is as yet only in very small part utilized for road metal, and for «granolithic» pavements. Blast-furnace slag is now utilized in several ways, notably in the manufacture of Portland cement. In a number of cases the accumulations of other kinds of slag on the sites of ancient smelting works have, in modern times, been again put through the furnace to extract the metals left in them, with profitable results. Some of the refuse from the old silver mines of Laurium has been bought up by capitalists for this purpose. One instance though not of very recent date, may be given where, by the salvaging of a by-product, a fortune was very quickly amassed. About 1840 Mr. Askin of Birmingham discovered a method of separating cobalt, in the form of oxide, from nickel, two metals which were very difficult to separate. This oxide of cobalt was at first a waste product, but before very long it was put into the hands of potters, who readily bought it up to produce a blue color on their ware, at the rate of two guineas per pound. Among comparatively recent instances of utilization of by-products and waste products in the chemical industries, we may refer to the importance of the substances now developed from coal tar (q.v.), and the great value of some of them in the manufacture of dyes. Another example is the recovery of binoxide of manganese in the production of chlorine for the manufacture of bleaching powder by Weldon's beautiful process. Formerly for every 100 pounds of bleaching powder made about 100 pounds of the native oxide of manganese were required. Now this manganese is recovered and used again and again in the process, with only a loss of about 5 per cent to make up each time it is returned to the chlorine still. The earlier methods of recovering manganese were not nearly so perfect, and, therefore, were not much used. A process for the utilization of chemical waste on a great scale is Chance's method, patented in 1888, of recovering sulphur from alkali makers' black-ash refuse. A British automobile manufacturing concern salvages 1,200 gallons of cutting oil a week from scrap metal, this oil being used again with the addition of 10 per cent of new oil, the latter being the actual amount of unrecoverable waste. Another establishment treated in one year 83,400 pounds of lathe waste, recovering 2,292 gallons of cutting oil. Large quantities of machine oil are recoverable from rags and cotton waste used for wiping machinery. The process of oil recovery so cleanses the wipers that they are useful again. The year's report shows 350,000 wipers treated, and an annual replacement of only 15,000 new cloths required; and a recovery of more than 5,000 gallons of oil — the total cost of the operation being less than $1,000.

Passing to vegetable substances, the various materials besides rags used in the manufacture of paper may be first noticed. Straw, wood, and esparto fibre, if not exactly waste products, were at least undeveloped substances before they became, as they now are, so largely used in paper making. Old ropes, flax and jute-mill waste, old or torn pieces of paper of every kind, are all serviceable in paper-mills or in the manufacture of millboard. In the pulp of the latter old newspapers bulk largely. Cotton waste is much used by mechanical engineers for cleaning purposes. Sawdust is employed in several ways: in the manufacture of artificial wood, which is pressed into many architectural forms; as a source of oxalic acid, and of pyroligneous acid; and, when compounded with magnesium chloride, as a durable, warm and resilient coating for the cement floors of fireproof buildings. Chips of yellow pine from Southern shipyards yield turpentine and rosin to the waste industry. One of the most interesting developments of all is the manufacture of artificial silk from the wood waste of saw-mills and carpenter shops. The timber wastes of the United States are prodigious; the estimate for 1913 placing the total at 150,000,000 tons. One of the most effective activities of the Forest Service is directing the salvaging of this waste and its delivery into the hands of establishments which will utilize it. The waste liquors of the wood-pulp industry yield alcohol, adhesives, tanning agents and thymol; and a recently discovered Norwegian process for separating the lignin makes that substance available for fuel — in amount nearly or quite enough to furnish all the heat required in making the pulp. Molasses, a waste product of sugar making, besides being a food, yields large quantities of industrial alcohol at low cost; and, as a by-product to this manufacture, yields valuable potash salts. Corkcutter's waste has become of high importance in the manufacture of linoleum and cork carpet. Cork mattresses and life-preservers, compressed with shellac into new bottle corks, for lining refrigerators and as a substitute for shavings in vinegar making. From the bark stripped from osier wands the useful medicine salicin is now made. In days not so long past the spent madder of our large dyeworks was suddenly raised from a useless to a valuable material by treatment with sulphuric acid, which converted it into the dye called garancin. One of the most interesting examples of what has been done in converting a waste animal product into a highly useful material is seen in the case of waste silk. Cocoons do not yield half their weight of reeled silk, but the remaining «waste» portion has, through the ingenuity of an English inventor, become the raw material for a large spun silk industry. In Venice artificial flowers for ladies' headdresses are made of imperfect cocoons. The various kinds of waste from woolen mills and from the cutting up of woolen fabrics are either worked up again, the short fibre into mungo and the long fibre into shoddy, or it is used for felt or ground into flock for paper hangings. Glue (q.v.) is made from parings of hide and bone, which also yield glycerine. The turnings and dust of the ivory and bone turner have various useful applications. From almost any waste animal matter, such as parings of horns and hoofs, hair, blood, leather cuttings and even field mice, is made the whole list of the invaluable cyanides. The waste of leather cutting is compounded with waste or scrap rubber in the production of a waterproof artificial sole leather. Clippings of fur skins are made into hats and fish scales into artificial pearls. The waste of mother-of-pearl left by button cutters is converted into a fine powder of peculiarly beautiful silky lustre, and used in making artificial flowers and fine wallpapers. The skim-milk residue of butter factories is made into a grade of condensed milk or treated as a source of commercial casein, the whey being worked for its content of milk sugar. The waste bone-charcoal of the sugar refineries is treated with sulphuric acid to make the valued bone phosphate fertilizer. Other materials regularly dealt in by the dealers in waste include old twine, old oilcloth and carpets, books and magazines, old hats, broken glass and old bottles, moss, hair, fur, bones and many others.

The enormously increased prices following the entrance of the United States into the World War gave a market stimulus to the waste industry, owing to the increased values which waste assumed. The larger establishments found it profitable to organize individual salvage departments, in some cases costing into the millions; equipped with complete outfits for treating all sorts of waste. It has been stated that the national savings during the war in scrap metal, wool waste, paper, rags, bags and cotton linters were more than $1,500,000,000.

By destructive distillation of coal Ford converts a ton of bituminous into 8,000 cu. ft. of gas, 10 gals. of gasoline, 20 lbs. ammonium sulphate, 30 gals. crude light tar, 3 gals. creosote oil, 2 gals. crude lubricating oil, 10 lbs. grease and has left 1,500 lbs. coke. The net money loss of present practises is estimated at $2,000,000,000 which could be salvaged by the proper use of coal including doubling the horse-power and salvaging the ammonium sulphate, benzol, tar, creosote oil, etc.

Smaller establishments disposed of their waste at good prices to one of a large and competitive throng of dealers. The waste trade has its own directory which lists more than 30,000 concerns who either deal in wastes or who use these wastes as raw material in their own industries. Some 6,000 of these dealers are in foreign countries, and not only sell their own domestic waste, but buy at good prices the wastes of American industries. Consult Koller, T., 'The Utilization of Waste Products' (London 1918); Kershaw, J. B. C., 'Recovery and Use of Waste' in 'Industrial Chemist' (1926).

WASTE LANDS, uncultivated and unprofitable tracts in populous and cultivated countries. The term waste lands is not employed with reference to land not reduced to cultivation in countries only partially settled. There is a large extent of waste lands even in Great Britain. Of the total 56,107,000 acres which it contains (excluding water), only 30,280,000 acres are arable land and improved pastures; 2,736,000 acres are occupied by woods and plantations. In Scotland 9,710,000 acres were rough grazing land in 1926, generally at considerable elevation and little improved by art. In a recent year in Ireland 8,000,000 acres were uninclosed pasture, 3,000,000 acres were mountain and bog; and the remainder was unimproved and unproductive.

In the United States, much of the land now practically waste is in this condition merely because the time has not yet come for profitable development of its capacities. That brought under cultivation is remarkably productive. The report of the Department of the Interior declares that on 1 July, 1931, the acreage of «unappropriated and unreserved lands» in the United States was as follows:

	Surveyed lands	Unsurveyed lands	Total
Arizona	7,489,400	6,877,000	14,366,400
Arkansas	184,170	....	184,170
California	10,833,154	5,213,794	16,046,948
Colorado	6,536,475	1,120,665	7,657,140
Florida	15,807	5,900	21,707
Idaho	9,676,675	1,809,252	11,485,927
Minnesota	193,090	....	193,090
Montana	6,319,052	90,980	6,410,032
Nebraska	20,805	....	20,805
Nevada	30,133,644	21,265,652	51,399,296
New Mexico ...	13,198,947	1,185,048	14,383,995
No. Dakota	146,349	....	146,349
Oregon	12,889,846	92,411	12,982,257
So. Dakota	459,516	....	459,516
Utah	13,533,638	11,623,362	25,157,000

	Surveyed lands	Unsurveyed lands	Total
Washington	923,539	6,850	930,389
Wyoming	14,711,778	544,752	15,256,530
Total	127,265,885	49,835,666	177,101,551
Alaska	....	346,201,925	346,201,925
Grand total ..	127,265,885	396,037,591	523,303,476

WASTES, Disposal of City.—The public wastes of a city may be grouped into two very broad classes: sewage, including industrial chemical wastes; and refuse. The first class is specifically treated under the title SANITARY ENGINEERING and elsewhere in these volumes.

Refuse.—This second broad class of city wastes includes garbage, ashes, street sweepings, rubbish, dead animals, night soil, swill, slops, offal, trade wastes, and other putrescible and nonputrescible wastes, except the liquid-carried wastes normally discharged into sewers. With the increased use of garbage grinders quantities of garbage are being discharged into the sewerage system and handled in the same manner as the wastes discussed under SANITARY ENGINEERING—*Sewage Treatment.*

The primary consideration of the problem of refuse collection and disposal is proper sanitation. The public health significance of the problem differs with the nature of the waste material. Sanitary methods of handling and disposal of garbage, street sweepings which may contain manure, and certain other refuse that contain organic waste constituents are important because these wastes may attract and serve as food supplies for flies, cockroaches, and rodents. Rubbish, paper, and other dry wastes may serve as harborage for rats and insects. Nuisances resulting from improper handling of garbage and refuse include disagreeable odors, breeding of insects and rodents, and unsightly, filthy esthetic conditions.

The second most important consideration is the attainment of satisfactory results with a minimum expenditure of funds. Refuse collection, storage, and disposal are fundamentally engineering problems requiring the application of the principles of engineering design and management. The problems vary in each community but their complexity is common to all. A thorough study of local conditions and technical problems that are encountered in the initiation and operation of a satisfactory refuse disposal program at lowest possble cost should come under the jurisdiction of a sanitary engineer or sanitarian qualified to undertake this type of study.

Refuse is a general term that includes many different substances from a great number of sources, including all solid or semisolid waste materials with the exception of excreta. It may be classified as to source, examples being market refuse, stable refuse, house refuse, and street refuse; but it is generally divided into several classifications as to type: (1) garbage; (2) ashes; (3) rubbish; (4) dead animals; (5) night soil; (6) street sweepings; and (7) mixed refuse. Each of these classes of refuse will be described briefly and the different methods of collection and disposal will be discussed subsequently.

(1) Garbage comprises all putrescible wastes of vegetable or animal matter originally intended for or associated with food for human consumption. It includes all waste materials from kitchens of homes, restaurants, hotels, and institutions, together with the putrescible organic waste materials from markets, groceries, and abattoirs. It requires careful collection, storage, and handling, especially during warm weather, when it decomposes quickly and gives off offensive odors. As mentioned previously, it also attracts flies, insects and rodents. However, garbage is also the most valuable of any of the classes of refuse, as it may be used in feeding hogs and it may yield grease and fertilizer by reduction processes which are described under methods of refuse disposal. Research is being carried on in the United States at the present time to improve the methods of composting garbage to convert the easily putrescible organic matter into a stabilized humus usable as fertilizer.

(2) Ashes are the waste products of coal and other fuels used for cooking, in the heating of homes and for industrial purposes. The amount of ashes produced fluctuates with the seasons, being highest in the winter. The amount also is dependent upon the geographical location and climatic conditions. Ashes may differ considerably in quality depending upon their source and the type of fuel used. They may also contain considerable amounts of unburned combustible material, some incombustible material, such as tin cans and other metallic substances, broken glassware, and crockery. The amounts of ashes being produced have decreased considerably in the past few years because of the increased amounts of gas and oil being used as fuels.

(3) Rubbish is any dry nonputrescible household or business wastes that are not classified as garbage or ashes. It includes paper, rubber, rags, cartons, excelsior and other packing, discarded furniture and other wood, glass, crockery, leather, sweepings, metal, and other articles. It is synonymous with the term "trash." Rubbish is normally not putrescible, but may contain floor sweepings contaminated with pathogenic bacteria or cans containing small amounts of putrescible materials.

(4) Dead animals may be collected by the municipal refuse collection service from stables, riding academies, dairies, zoos, race tracks, and even visiting circuses and rodeo troupes. In some cities private companies may perform this service, although they usually do not collect small animals, the latter being collected by the cities. Dead animals are usually disposed of by burial, incineration, or reduction. They should be buried deep enough to prevent dogs or other carnivorous animals from digging them up. Larger animals, such as horses, cattle and mules, are generally skinned and their hides sold.

(5) Night soil is a term applied to the solid and liquid human excrement collected from box-and-can toilets, private privy vaults, and other receptacles for excreta disposal in those areas without water-carriage sewer systems. The term "night soil" originated from the fact that before the advent of sewer systems large numbers of privy vaults were then in use and when they became full were emptied at night. This method of human waste disposal has been outlawed in the cities of the United States although many are still in use throughout the country in outlying sections of the larger cities as well as in the smaller towns and rural areas. It is primarily a rural problem.

In many parts of the world, notably Formosa, Japan, China, and India, the night soil is of considerable economic value as fertilizer. In South Africa over 100 cities and towns mix night soil with garbage and other putrescible organic waste materials in compost pits to produce fertilizer for their agriculture.

(6) Street sweepings consist of the dust from the wear and tear of the road surfaces, paper, leaves, branches of weeds and trees, cigarette and cigar butts, sweepings from stores and sidewalks, materials that have fallen from vehicles, and many other types of litter. Education of the general public, backed up by effective police control, can help to reduce, if not eliminate, unnecessary littering of the streets which adds to the expense of street cleaning. New York City has recently instituted a program to promote a cleaner city by empowering all supervisory personnel of the Department of Sanitation with police power to hand out summons to appear in court for any violation of the Sanitary Code, including the promiscuous littering of streets with paper and other refuse. (See STREET CLEANING.)

(7) Mixed refuse consists of one or more combinations of the various refuse materials of a community to facilitate their collection and disposal. Rubbish and garbage are often collected together, when the mixture will be disposed of by incineration. Other common combinations are rubbish and ashes, combustible, and noncombustible mixtures, one mixture being placed in one container and the remainder in another, dependent upon the final method of disposal. With the sanitary land-fill method it is unnecessary to separate the refuse into its component parts.

Quantities and Characteristics of Refuse.—The quantities of refuse in any community are dependent on many factors, including climate, season, habits of the people, geographical location of the community, nature or type of community, economic period, and efficiency of collection service.

Garbage weighs between 30 to 55 pounds per cubic foot, dependent on moisture content, which varies from 50 to 70 per cent. Ashes weigh from 40 to 50 pounds per cubic foot, while rubbish is much lighter in weight, varying from 20 to 25 pounds per cubic foot. In cities requiring that garbage be drained and wrapped the weight is lowered proportionately to the amount of moisture removed.

The total weight of refuse in a city varies considerably but averages about 2 pounds per capita per day. Of the total weight, garbage constitutes about one fourth of the weight and one fifth of the volume, or varies from a minimum of about 0.3 pounds to a maximum of 2.3 pounds per capita per day in different cities. Rubbish constitutes about one third of the weight and one half of the volume of the total amount of refuse of a city. This variation in weight and volume must be carefully considered in providing an efficient, economical, and sanitary refuse collection service.

The composition of refuse varies widely, making it almost impossible to predict the amounts of its different components. Therefore, it is very essential to obtain accurate weights and volumes and to maintain accurate records to determine costs of refuse collection and disposal. Chemical analyses may aid in determining the value of by-products obtainable, such as grease, feed for hogs and cattle, or fertilizer.

Municipal Refuse Disposal.—The problem of municipal refuse disposal is divided into three separate phases: house treatment; collection; and disposal.

House Treatment.—This consists of the handling or treatment of refuse by the producer in the home or business place before collection. The treatment that it receives plays an important role in sanitation. Odors may be almost eliminated or reduced for several days if garbage is drained and wrapped, or mixed with ashes and rubbish in the receptacle for collection. The most important nuisance from rubbish is due to loose paper. Mixing of garbage with the rubbish moistens the paper and helps to eliminate this problem.

The most common method of house treatment in the United States is the separation of the refuse into two cans. The garbage is usually placed in one can, and the rubbish and ashes are placed in another. This is a very satisfactory method where either hog feeding or reduction is the method of disposal.

The receptacle used for the storage of refuse before collection should be of material suitable to receive the wastes and be provided with a tight-fitting cover. In most cities metal receptacles are recommended for storage of garbage and ashes. The size of the container required is partly dependent upon the amount of garbage and refuse to be stored between collections, but it must not be so large that it is difficult to empty into the collection vehicle. The maximum size recommended for separate garbage storage and collection is 10 or 12 gallons, and for combined garbage and domestic refuse a 30-gallon container with a weight limit of 65 pounds when full is preferable for easier handling.

In New York City very large enclosed metal containers are placed in certain locations where large volumes of refuse are produced, such as at hospitals, schools, markets, and apartments. When full, they are lifted onto a large truck by means of a hoist, an empty container is substituted, and the full container is hauled away.

Collection of Refuse.—The method used in most communities in the United States for the collection of refuse consists of a gang of two or three men with a vehicle. The men pick up the refuse containers from each house and place the cans or their contents into the vehicle and transport it to the place of disposal. The vehicle may be an open-body type or the more sanitary, enclosed, compaction-type truck, of which there are several designs. The vehicles with compacting units have a hauling capacity of 35 to 50 per cent more than the open-body trucks. Based on an average wage of $1.50 per hour, it was shown in a 1952 survey of several California towns that the average labor cost of the pickup operation was $3.71 per ton and the total collection operation amounted to $5.37 per ton.

Problems considered in the efficient operation of any refuse collection system are: frequency of collection; time of collection; type and size of vehicles; number and efficiency of men in collection crews; length of haul to place of disposal; method of administration, whether by municipal personnel, by private contractors, or by a combination of the two.

Factors considered in the selection of refuse collection trucks are: ease of loading; low-loading height; speed of loading; compactability; reliability; maintenance costs; and original cost of vehicle.

Disposal of Refuse.—The method selected for the disposal of refuse should perform its function with the least production of nuisances and in the most economical manner. The refuse disposal methods include the following: dumping upon the land; dumping into the sea; incineration; sanitary landfill; hog feeding; garbage grinding; reduction; and composting.

Sufficient space is not available to discuss all of these methods in detail, and since dumping on land, dumping at sea, and incineration have already been covered adequately under the title SANITARY ENGINEERING, they will not be discussed in this article. An excellent discussion of sanitary landfill, hog feeding, and garbage grinding will also be found in the above-mentioned article but additional comments will be made here. The two other methods, reduction and composting, will be discussed in subsequent paragraphs, as they have not been included elsewhere in these volumes.

Sanitary Landfill: This method of refuse disposal is distinguished from the open dump by the fact that the garbage, ashes, street sweepings, and rubbish are dumped in layers of controlled depth and width in a trench or depression and the material compacted and covered at the end of each working day with a layer of clean dirt, sand, or ashes to a depth of 2 or 3 feet, to exclude rodents and prevent the escape of odors or the outbreak of fires. A single bulldozer or dragline with an operator can operate a landfill handling 3,000 to 4,000 cubic yards of refuse per year. An area of 0.75 to 1.5 acres per 10,000 population per year is sufficient where the refuse is placed in layers to an average depth of 6 feet.

Hog Feeding: The feeding of garbage to hogs is operated as a profit-making venture. With this being the primary objective, public health departments have considerable difficulty in attempting to persuade hog farmers to maintain some semblance of sanitation in their operations. The nature of the activity itself together with economic and political considerations makes it almost an impossibility.

In the United States most public health authorities frown on hog feeding as a method for the disposal of raw garbage because of the high incidence of trichinosis infestation among these hogs. The United States Quarantine Regulations now require that garbage fed to hogs to be sold in interstate commerce must be heated at 212° F. for 30 minutes. Most health authorities recommend the heating of garbage which may contain trichinae larvae to prevent hogs from becoming infected with these worms that may infect man upon the consumption of insufficiently cooked meats from garbage-fed hogs.

Many states have recently required the heating of garbage at a minimum temperature of 145°F. for not less than 30 minutes to prevent the transmission of vesicular exanthema, a disease of hogs almost wholly confined to farms feeding raw garbage.

In England and Wales in 1940 a program for the separate collection of garbage was instituted on a national scale in order to salvage this material for the feeding of hogs due to the serious shortage of imported animal foods. Over 60 sterilization stations were built for the purpose of heating the garbage to 212° F. for 1 hour to destroy the virus of foot-and-mouth disease which had caused many extremely costly and wasteful outbreaks of this disease on their hog farms.

Garbage Grinding: Every year, increasing numbers of garbage grinders are being installed in homes for the disposal of garbage into sewers. In the past few years several municipalities, following the example of Jasper, Indiana, have installed home grinders on a citywide basis. Jasper purchased the units in large quantities at a low price, resold them at cost to the home owner under a monthly-payment arrangement, and provided maintenance, all for a total cost of $0.66 per family per month, including interest. Many cities prohibit the installation of home grinding units because of the increased amount of organic sludge load placed on the municipal sewage sludge digestion facilities already operating at maximum capacity.

Reduction: This is a method of processing garbage and dead animals to recover grease and produce tankage used as livestock feed or as fertilizer. Two general procedures for garbage reduction are in use, the cooking method and the extraction method. In the cooking method the garbage is cooked in closed tanks to prevent the escape of odors. The grease and water are then pressed out of the cooked material and the grease is skimmed from the surface of the water. Additional grease is extracted from the filter cake by an organic solvent such as naphtha or gasoline. The filter cake is then dried, ground, and sold as tankage for the manufacture of fertilizer or cattle feed. In the extraction method, the garbage is first ground, dried, and then treated with an organic solvent as by the previous method. About 1 to 8 per cent of grease and from 10 to 20 per cent of tankage by weight may be recovered from garbage. During the past few years many plants have been abandoned as unprofitable either because of operating difficulties from escape of odors or because of explosive hazards.

Composting: This is a biological method of altering the composition of garbage and other organic material, resulting in a stable humus-like end product usable as fertilizer. The composting process consists of placing the raw materials in piles or in concrete or brick cells, then allowing the mass to ferment through the action of bacteria and other microorganisms. Heat is generated, and the resulting high temperature, 140° F. to 180° F., is sufficient to destroy pathogenic organisms. Mixing of the mass is essential, varying from one or two manual turnings to continuous mixing by mechanical means. The mixing provides aeration so that the fermentation will proceed under aerobic conditions in preference to the slower-acting anaerobic process.

This is an age-old process for the conservation of organic waste products, including night soil, which has been developed with considerable success in many countries, notably Denmark, France, Italy, and throughout the British Empire. In South Africa this method of composting has been developed by using garbage, night soil, bat and kangaroo manure, farm manure, and abattoir wastes as raw materials for the production of fertilizer. The chief operating difficulties with composting are fly breeding, odors, and proper drainage.

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WATAUGA ASSOCIATION. See TENNESSEE—*History.*

WATCH HILL, post village in Westerly Township, Washington County, R.I., on the Atlantic Ocean, and about three miles southeast of Stonington, Conn. It is near Watch Hill Point, a promontory forming the extreme southwest point of Rhode Island. The place has a fine beach and ranks next to Newport and Narragansett Pier, in Rhode Island, as a popular summer resort. Pop. (1950) c.500.

WATCHMAKING, Modern. The history of watchmaking covers nearly 500 years of dramatic technical progress and intense international rivalries. In that period four nations have struggled for supremacy in the industry, even resorting to the use of spies and smuggling, and today (1950) the competition is as keen as ever.

Structure of Watch Movements.—The jeweled watch of quality (15 to 23 jewels) is a complex mechanism consisting of 135 to 140 pieces and requiring from 2,500 to 3,000 manufacturing operations. Its structure is described by Walter Kleinlein of the Waltham Watch Company as follows. There are four principal assemblies in a watch movement: (1) the power plant consisting of the barrel, the mainspring, and its attachments; (2) the train of toothed wheels and pinions, through which the power of the mainspring is transmitted; (3) the escapement assembly, which stops and releases the transmission of power; (4) the balance and hairspring assembly, which governs the period of time in which each release of power is made. The hands and dial assembly complete the operations by indicating the timekeeping performance of a watch.

The escapement is one of the most important elements in the watch, and its operation is worthy of more detailed description.

Fig. 1 shows a diagram of the detached lever escapement, which consists of four parts: (1) the escape wheel; (2) the pallet and arbor assembly; (3) the adjustable banking pins; (4) the balance staff and roller assembly. The energy of the mainspring is transmitted through the train to the escape wheel. Pressure of the teeth of the escape wheel on the pallet jewels sets up an oscillating motion of the pallet and fork, which is transmitted to the balance wheel and hairspring. The accuracy of the watch is controlled by the precise design and adjustment of these parts to each other, and by the reduction of friction through the use of jeweled bearings. Quality jeweled watches require adjustment for four basic factors: (1) isochronism, (2) timing, (3) temperature, and (4) position.

Isochronism is the maintenance of a constant rate of operation as the watch runs down after winding. In a clock this is accomplished by the use of a pendulum of constant length and weight swinging under the constant influence of gravity. In a watch the rate is kept relatively independent of the changing force of the mainspring by the oscillation of a poised balance wheel of constant mass and fixed center of gravity, operating under the constant influence of the hairspring.

Isochronism involves two major problems of design: (1) The balance wheel must be poised, that is, its weight must be uniformly distributed so that the force of gravity will not affect its oscillation. (2) The design of the balance wheel and the hairspring must be such that their oscillating motion does not alter the force exerted by the hairspring or the resistance offered by the inertia of the balance wheel.

Poise is obtained by the adjustment of radial screws in the rim of the balance wheel. Metal is removed from the underside of the head, or heavier screws are added above, until the wheel, when mounted in poising calipers or poising tool, rotates freely and is not more disposed to stop in one position than in another.

Timing.—Timing is obtained by adjusting the

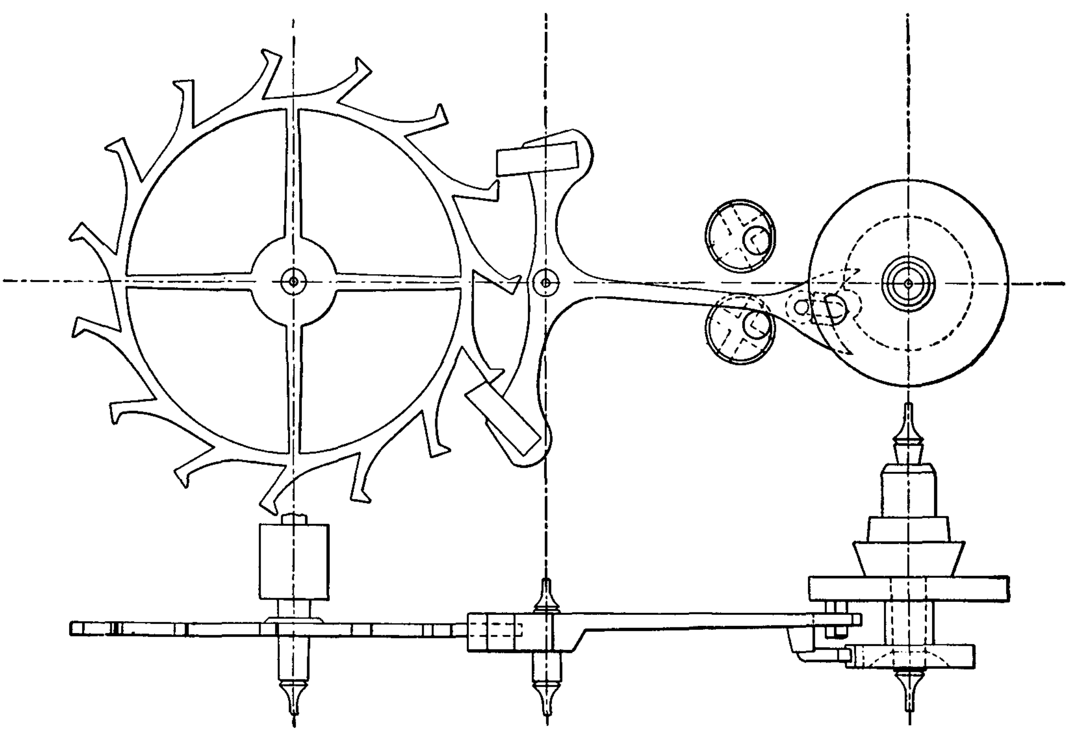

FIG. 1. Double roller escapement.

strength of the hairspring to the oscillating force of the balance wheel. This is called *vibrating*, and involves obtaining the correct number of oscillations per hour for which the watch was built. In modern watches this consists of 18,000 oscillations per hour. This means that through the operation of the escapement, the balance, and the hairspring, the train of wheels (and therefore the timing) of a modern watch is stopped and again released 18,000 times per hour, or 432,000 times in a 24-hour period.

Adjustment of steel hairsprings for changes in temperature is accomplished by making the rim of the compensation balance wheel of two

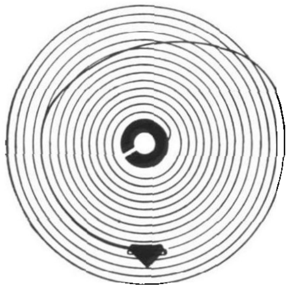

FIG. 2. Hair spring.

sections of bimetallic metal, fitted with adjustment screws (Fig. 3). The outer strip of brass is brazed to the inner strip of steel. An increase in temperature expands the whole wheel, tending to increase its inertia, but the greater expansion of brass compared to steel shortens the radius of curvature, as in Fig. 4, counteracting the effect of simple expansion. Adjustment is accomplished by shifting the screws to various positions on the rim.

Methods of Correcting Temperature Variation.—Fig. 4 shows an extreme distortion of both sections of a bimetallic compensation balance wheel in high temperature. The free ends curve

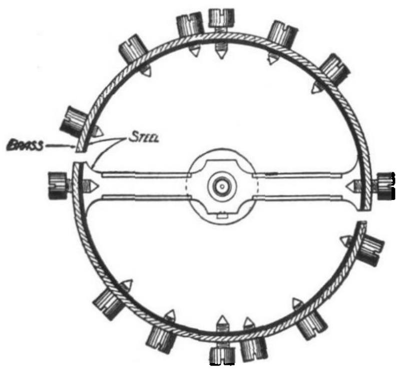

FIG. 3. Bimetallic balance wheel.

inward from true concentric as the temperature increases from normal; shifting screws to different holes toward the cuts and in opposite pairs causes additional weight to move nearer center. This alteration supplies a gaining rate to overcome the loss produced by the increased length and lessening of elasticity of the steel hairspring.

Inversely when the temperature decreases the free ends curve outside of true concentric. This causes a loss at the same time that the hairspring supplies a gaining rate due to its becoming shorter and stronger. In this case screws are moved away from the cuts when the variation is above tolerance and a correction is required.

By using a solid monometallic balance wheel and a hairspring, each containing alloys with a very low coefficient of expansion for temperature changes, there is no need for mechanical temperature adjustment. These alloys have the further advantages of being virtually nonmagnetic and rustproof.

A solid rim monometallic balance wheel is shown in Fig. 5.

Adjustments are made for as many as six positions: stem up, left, right, down; dial up and dial down. Approximate adjustment is obtained by poising the balance wheel, thereby

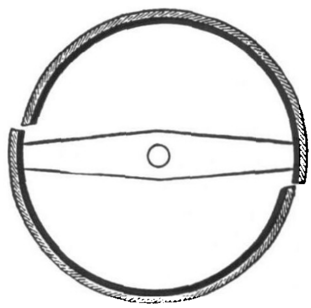

FIG. 4. Bimetallic balance bent by high temperature.

eliminating the effect of gravity upon the oscillation of the wheel. Other adjustments are made to correct the effect of gravity on the hairspring and the various jeweled bearings of the movement.

Production.—The production of watches began in central Germany about 1500, and from this section came the bulky timepieces known as Nürnberg eggs. Two hundred years later the leadership of the industry passed to the English, for German ingenuity was no match for specialized English craftsmanship. English leadership lasted some 140 years, but by 1840 the Swiss had

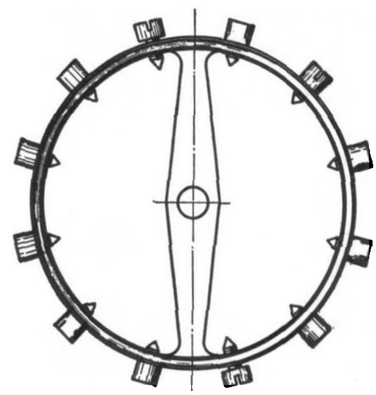

FIG. 5. Monometallic balance wheel.

acquired such superlative skill in the same manufacturing methods used by the English that they, in turn, seized the dominant position in the watch industry. The craftsmanship of Swiss watchmakers has probably never been surpassed, but in the 19th century manual skill was not sufficient to maintain a position of leadership in the industry, and first place was forfeited to the United States. Beginning in 1850, a new firm, later known as the Waltham Watch Company, applied to watchmaking a combination of mechanical ingenuity and organizing skill that we have since come to call mass production. It was clearly demonstrated in Philadelphia at the Centennial

Exhibition of 1876 that better watches could be made for less money by this revolutionary "American system," introduced by Aaron Lufkin Dennison in 1850 and developed by Waltham. The results were so spectacular that the methods were soon copied both at home and abroad, and eventually they were adopted as standard in the industry.

The first successful domestic competition came from the Elgin National Watch Company, which was founded in 1864. There followed a series of nearly 60 American firms which depended largely on domestic parts (except jewels) for the production of complete watches. Of these firms only Elgin, Hamilton, and Waltham remain.

In the early years of the industrial revolution, English methods of watch manufacture were the acme of manufacturing efficiency, but by 1850 they were fast becoming archaic. In that year Aaron Lufkin Dennison, founder of the Waltham Watch Company, visited England in search of technical information and reported as follows:

"I found that the party setting up as manufacturer of watches bought his Lancashire movements—a conglomeration of rough materials—and gave them to A, B, C, and D, to have them finished; and that A, B, C, and D gave out the different jobs of pivoting certain wheels of the train to E, certain other parts to F, and the fusee cutting to G—dial making, jeweling, gilding, motioning, etc., to others, down almost the entire length of the alphabet."

He returned home convinced that competition with English firms would present no real difficulties to American watchmakers, if the latter used the interchangeable system and if manufacture on a large scale was adopted.

The interchangeable, or American, system, as it is called in the watch industry, was not originated by Dennison. He found it in a high state of development at the Springfield (Mass.) Arsenal, where it was used in the manufacture of rifles. The fundamentals of mass production had been employed by Eli Whitney (q.v.) in making firearms in 1798, and the system had been in successful use for over 50 years, when Dennison attempted to apply the same principles to watchmaking. It seemed obvious to Dennison that these mass production methods were applicable to the watch industry, but the sober judgment of the times was against him, and he was dubbed the "Boston Lunatic." There were, in fact, four major problems, the magnitude of which was not adequately foreseen. The seriousness of each problem was discovered separately, and each required a fresh start, one of them involving bankruptcy.

The first problem was to design a watch that could be produced efficiently by mass production methods. It was also desired to offer a conspicuous improvement over the watches then commonly in use, so that novel design would help to gain public acceptance for the product and the new method of manufacture. With these ends in mind, the first model produced by the Waltham Company was an eight-day watch having two mainsprings to furnish the additional power required for an interval of eight days with one winding. A few of these watches were made, but, as they did not keep good time, the model was promptly abandoned in favor of a standard 36-hour watch of the English lever type.

The second error was in design and construction of machine tools, sufficiently accurate for watchmaking and dependable enough as regards uniformity of output, for use in a mass production factory. Before the company was started, Dennison designed, built, and tested some of the key machines that were needed. Unfortunately the tests were not as exhaustive as the circumstances required, and the machine failed to meet the necessary standards of accuracy and uniformity. The machine-tool industry of that day had no equipment capable of such precision as four ten-thousandths of an inch when working on parts so small that a magnifying glass is needed to inspect them. It was therefore necessary to redesign the machines, to test and redesign again, until satisfactory accuracy and uniformity could be maintained day after day on many thousands of watch parts.

The tremendous capacity that is the great virtue of mass production requires that operations be conducted on a grand scale, and Dennison miscalculated the size of the undertaking. Having little capital of his own, he sought financial assistance from the Boston firm of Howard and Davis, and from Edward Howard's father-in-law, Samuel Curtis. With $30,000 obtained from these sources, the original firm attempted to mass-produce a watch containing approximately 150 parts and requiring some 3,700 distinct operations. The time and money required to bring such a venture to the point of profitable operation, and the ultimate size of the undertaking, were beyond the range of foresight. "It was more than three years," wrote Edward Howard, "before the establishment had fairly and fully started in the business of making watches, and then it was found that it would require ten times as much room as had been provided, and we set about building a very much larger factory." The new factory was built in 1854 on the banks of the Charles River at Waltham, Mass.

The most serious of the many problems facing the watch industry then and later was that of mass distribution, the Siamese twin of mass production. Little thought was given to marketing when the business was started. Both Howard and Dennison were widely acquainted in the jewelry trade, Howard as a manufacturer of clocks and Dennison through 10 years' experience as a wholesaler of watches in Boston. There was no difficulty in disposing of the output of the original plant in Roxbury, just outside of Boston, but when production in the new plant at Waltham reached 100 watches per month, marketing became the crucial function of the business. The need for wider markets came at a time (1857) when general business was in a state of severe depression. The problem of expanding the company's markets in the face of a collapse of general business activity put too great a strain on financial resources which had never been really adequate. As a consequence, the company went into bankruptcy and was sold at auction to Royal E. Robbins, a New York importer of watches.

The bankruptcy of the Waltham Watch Company throws dramatic emphasis on the hazardous nature of mass production. Four New England businessmen lost about $150,000 in the original Waltham venture, and Dennison failed three times more before he finally applied his ideas successfully to the manufacture of watch cases in Birmingham, England. The difficulties experienced in 1850 still handicap the efforts of businessmen in the use of these principles, and the number of failures in mass production industries is alarmingly high.

The chief causes of these failures are three in number. To begin with, few, if any, complex products are mass-produced in their entirety; some parts can be made more efficiently by less highly mechanized methods. In 1863, Edward Howard wrote: "The interchangeability of parts, however, was found not to be practical in the finer parts; never has been to this day and never will be." This is the technical hazard in the use of mass production. Suppose, however, that automatic machinery *can* be used for most of the expensive operations, financial problems then become paramount. The purchase of so much intricate machinery calls for a vast outlay of funds, and it may require more money than can be attracted to the venture by the prospect of large profits. As the need for more and more capital develops, investors become reluctant to increase their contributions, and if profits are not promptly realized, the business is likely to die of financial strangulation. But even though the technical and financial problems are successfully solved, the enterprise may fail by reason of its own fecundity. The volume of output tends to increase with each rise in productive efficiency until it reaches unforeseen proportions and becomes a drug on the market. The venture then suffers that most common of all business disasters, failure in the field of marketing.

Marketing.—The production of watches by modern methods has been limited by the means for marketing them. Each improvement in watchmaking machinery and methods poured a new flood of watches on the market and forced the development of better and cheaper methods of distribution. The production of watches in the United States increased more than a thousandfold after 1854, and the resulting competition became extremely sharp. Only a few domestic concerns have been able to solve the problems of marketing on such a rapidly rising scale. In all, there have been more than 10 failures for every success in the American watch industry.

The machine tools used in the early years of the American system were an improvement over the standard English equipment in that they could be made to "repeat" the production of a given part easily and with great exactness. They were better machines, but they were not fundamentally different; the second major development —that of automatic machines—was accomplished gradually.

At first, automatic machines were frowned upon by management as well as workmen. Each machine in use required the entire attention of an operator, and the notion that a mechanical device could produce precision parts while the operator's back was turned did not seem practical. The first semiautomatic machines were therefore built and tested by Waltham inventors without the knowledge of management, but the results of the test were so remarkable that policy was reversed and subsequent developments were rapid. Even with the combined support of management and labor, the task of the inventors was a long one. The design of fully automatic equipment for multiple operations on plates and pinions was not completed until the last decade of the 19th century. Much of the best work in this field was done by Duane H. Church, who was employed by the Waltham Company from 1882 to 1905.

By 1879, the development of semiautomatic machinery had carried production at Waltham over 98,000 watches per year, and competitors—both domestic and foreign—were expanding their production by the same means. The market could not absorb so much at customary prices, and price cutting became common.

In addition to this, other efforts were made to expand the market without resorting to major changes in distribution methods. The appeals of variety and style were used in an effort to reach more customers and to stimulate repeat sales. There was also increased activity in foreign markets, particularly in Latin America, in England, and in the British Dominions. These measures were effective for the time being, but the continued improvements in production methods and the rising output kept an unremitting pressure on prices, and new economies were necessary. By 1910 a change in the channels of distribution could no longer be postponed.

The channels of distribution for watches prior to 1850 started with the foreign manufacturer, who sold to a domestic importer, from whom the watches passed to the wholesaler, the retailer, and the consumer. This method of selling watches entailed four separate business risks and four layers of expense and profit, all added to the cost of manufacture. Although this may sound cumbersome and inefficient, it was well suited to the distribution problems of that time. In fact, it stood the test of use for centuries. In 1910, however, the manufacturer's agent (who had replaced the importer when production started in the United States) was dropped by the Waltham Company from the chain of distribution. Thereafter Waltham watches were sold by the factory sales force direct to the jewelry wholesaler. The economies achieved in this fashion were adequate for a considerable period of years, but Swiss competition inaugurated changes both in production and distribution that called for further readjustments in the industry.

The Swiss were not slow to grasp the significance of the American system of watch manufacture, nor did they hesitate in dealing with this menace to one of their most important industries. Their first step was frankly to admit the facts. In 1876 one of the Swiss commissioners to the United States, Édouard Favre-Perret, addressed his countrymen most earnestly on the subject. He said in part:

> "For a long time we have heard here of an American competition, without believing it. The skeptics—and there were many of them—denied the possibility of a competition at once so rapid and so important. . . . I sincerely confess that I personally have doubted that competition. But now I have seen—I have felt it—and am terrified by the danger to which our industry is exposed."

Swiss producers rose to the occasion with changes in many phases of the industry. They were quick to seize the essential elements of the American system and put them to use. But they were not content merely to copy; they developed a new variation of the method that was particularly well suited to their conditions. Watch movements, produced wholly or in part in Switzerland, were shipped to the United States to be completed, sometimes merely to be cased. This arrangement had many advantages. It permitted a maximum use of Swiss labor at a very favorable scale of wages, yet made it possible to market these watches as a domestic product. It also permitted the Swiss to take advantage of any differential in tariff between completed watches and parts. Advances in Swiss merchandising also were notable, especially of the wrist watch which became popular about the time of World War I.

In the matter of watchmaking machinery Swiss designers were particularly successful.

The Swiss government was active in support of the industry. Measures were taken to prevent overproduction. Schools were established to ensure an adequate supply of skilled watchmakers and designers. The watch industry of the nation was organized into a trust for large producers and a superholding company for smaller manufacturers. Through these organizations the Swiss government was able to take such measures as seemed desirable for protecting interests of the industry.

The aggressive efforts of the Swiss were so successful that imports of watches, movements, and materials from Switzerland into the United States exceeded $12,000,000 in 1929, but countermeasures were soon forthcoming. The Smoot-Hawley Tariff Act, passed by the United States in 1930, sharply reduced Swiss imports. The higher tariffs, combined with the depression in general business, carried Swiss imports of watches and parts down to $1,300,000 in 1932. Unfortunately for the American industry, the official figures on imports did not represent the true total; smuggling (judging by the newspaper reports and the court records) was a thriving industry. One American producer estimated that smugglers brought in between one and two million movements per year.

In the attempt to increase sales, Swiss ingenuity turned to devices for expanding the market as a whole. Manufacturers with Swiss affiliations were particularly active in radio advertising; one firm is reported to have spent $1,250,000 in 1937 on this form of advertising alone. Sales by the factory direct to retailers, and extensive consumer credit, were also employed to facilitate the rapid flow of watches to the widest possible market at the lowest possible price. These practices have been adopted by some of the old-line American producers, illustrating again the vigorous give and take of international competition. On the whole, progress in the marketing of watches has lagged behind production, and further substantial improvements in marketing methods are to be expected.

The watch industry as it existed just prior to World War II was largely confined to Switzerland and the United States (See U.S. Tariff Commission, *Watches,* pp. 3-6, Washington, 1946). There were then four producers of essentially complete jeweled watches of quality in the United States: Elgin, Hamilton, Waltham, and the Bulova Company. The Bulova Company was also an importer of Swiss movements and an assembler of Swiss parts. About 100 other firms fell in the class of importers and assemblers. In Switzerland there were 68 manufacturers of complete watches and 350 assemblers. In 1941 domestic manufacturers had about 38 per cent of the United States market, the remainder going to importers and assemblers of Swiss goods. Exports of the Swiss watch industry to the United States were from 10 to 27 per cent of the total value of all Swiss exports.

War Production.—M. Favre-Perret sounded the keynote of past rivalries in the watch industry, when he referred to the American market as the "milch cow" of the Swiss producers. In the future, however, military necessity will be added to the economic motives that have driven international competition at such a hard pace. It is even conceivable that national survival may hinge on the existence of a large and thriving domestic watch industry.

War has always been a stimulus to the American watch industry, but it was not until World War I that its essentially military character began to appear. During that conflict the government's demand for watches grew with the increasing importance of precise timing and coordination in military operations. At this point, also, there arose a demand for a new class of product, not directly related to watches, but requiring the same unique skills and the same, or similar, equipment. The first of the strictly military products of the watch industry was the time fuze for controlling the burst of shrapnel. This item was developed and produced—in cooperation with the government—at the Waltham plant during World War I. As the tools of war have become more intricate and powerful, the devices for controlling them have become more numerous, more delicate, and more precise; as the scope of war expands, the need for mass production becomes imperative. Productive capacity for a large volume and variety of precision parts is essential to military preparedness.

In World War II the entire watch industry was mobilized. The tremendous increase in the number of tanks, aircraft, and naval units established a new peak in the demand for military watches, especially the precision models for use in navigation. In addition to watches, chronometers, and small clocks, the industry produced a wide variety of precision parts and equipment. The line of fuzes was expanded to include percussion and base-detonating types. Other items in the list of war material were tachometers, speedometers, compasses, recording drift sights, precision springs, and rifle parts. Exact figures on the value of the munitions turned out by the watch industry during World War II are not available at the time of writing this article (1947), but the total has been estimated at between 100 and 200 million dollars. This figure, large as it is, does not give a true gauge of the importance of the industry to military operations. The items produced are vital to the navigation of ships and planes, to the effective operation of tanks, to the control of burst of heavy projectiles, and to a host of minor uses where timing is the essence of successful action.

It is customary in the United States to think of war production as infinitely expandable by converting peacetime industries. This has been approximately true, but the capacity of the watch industry is limited by the number of skilled workers. The peacetime force cannot be augmented by newly trained workers within the time permitted by the pattern of modern war. For example, it requires an average training period of one year to produce a fully skilled machine operator, and six years to train a die maker. Experienced finishers who assemble the components and adjust the finished mechanism need three years to become masters of their trade, and so on through the wide variety of special skills which require training and experience not provided in other peacetime industries. Carefully planned training programs were arranged by the industry with the cooperation of the government during World War II, but such programs are of limited value unless there is a large force of fully trained workers to carry on the conversion of equipment from the production of civilian goods to the manufacture of military items. At best, it requires one to two years to develop and to put into production a new military watch or similar device.

Labor Relations.—The workers of the watch industry as a whole have been doubly fortunate: first, in the liberal policies of the watch companies, and second, in the exceptionally able leadership displayed by their union organizer. With the growth of the Waltham Company some of the personal contact between management and the workers was lost, as was the case in most other industries. Under these circumstances the organization of the employees into a labor union was a logical development. In 1941 an organizing campaign was successfully conducted at Waltham under the auspices of the American Federation of Labor (AFL). The union subsequently retired from the AFL and set up an independent Watch Workers Union, extending the organization to include the employees of the Hamilton and Elgin companies.

The union has shown a sound regard for the difficult business problems of the industry, and has avoided the use of tactics that impede the successful conclusion of collective bargaining. Good relations have been further promoted by a temperate and cooperative attitude on the part of management. Industrial peace was maintained through the reconversion period following World War II, in spite of the controversial issues arising from wartime inflation and Swiss competition. See also CLOCK.

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CHARLES W. MOORE.

WATCHUNG, wä'chŭng, or **ORANGE MOUNTAINS,** New Jersey, a range of hills beginning at a point southwest of Paterson and curving to the southwest for about 40 miles before terminating in the area north of Somerville. The hills consist of two ridges at an altitude of 400 to 500 feet, lying largely in Somerset and Essex counties. The ridges are referred to as the First Watchung and the Second Watchung mountains. Of volcanic origin, the hills are composed of traprock (once a lava flow) covered by shale and sandstone, except where erosion has revealed the original igneous rock. During the Revolutionary War the First Watchung ridge, around Summit, served to deter the British from penetrating westward to George Washington's headquarters at Morristown.

WATENSTEDT-SALZGITTER, vä'tŭn-shtĕt-zälts'gi-tŭr, city, Germany, in Lower Saxony, about 15 miles south-southwest of Brunswick. The city was created in 1942 by the merger of scattered manufacturing centers, and now is organized into the city districts of Flachstöckheim, Gebhardshagen, Lebenstedt, Lichtenberg, Salzgitter, Thiede-Steterburg, and Watenstedt. Its heavy industry is centered on steel mills and a large smelter, the production of coke, and the manufacture of gas for most of northwest Germany. Within the city are oil wells, and iron and potash is extracted from mines at Salzgitter. Other products are chemicals, textiles, machinery, and foodstuffs. In 1937–1938 the government began to develop the area's abundant mineral resources and to establish iron and steel plants. The city became part of the Federal Republic of Germany (West Germany) after World War II. Pop. (1957 official est.) 102,100.

WATER, wô'tĕr, the best known and most abundant of all chemical compounds occurring in relatively pure form on the earth's surface. Oxygen, the most abundant chemical element, is present in combination with hydrogen to the extent of 89 per cent in water. Water covers about three fourths of the earth's surface and permeates cracks and crevices of much solid land. The polar regions are overlaid with vast quantities of ice, and the atmosphere of the earth carries water vapor in quantities from 0.1 per cent to 2 per cent by weight. It has been estimated that the amount of water above a square mile of land on a mild summer day is of the order of 50,000 tons.

All life on earth depends upon water, the principal ingredient of living cells. Its availability has made it the standard of the thermometric scale, and it also fixes many other weights and measures.

Physical Properties.—In comparison with most other substances, water has most unusual physical properties. It occurs and is in common use in all three states—solid, liquid, and vapor. Although of low molecular weight (approximately 18), it has a high boiling point. Neon, with very nearly the same molecular weight (slightly above 20), boils at −245.9° C. Water exists as a liquid through a long range of temperatures. At 374.0° C. and at a pressure of 217.7 atmospheres, water can no longer remain as a liquid, these being its critical temperature and critical pressure. The density of liquid water is unusual in that it increases slightly from its freezing point to 4° C., after which the density decreases with temperature rise, as in other liquids. Its boiling point is quite dependent on atmospheric pressure, being 100° C. at 760 millimeters (mm.; general pressure range at sea level) and about 84° C. at about 420 mm. The effect of pressure on the freezing point is not so marked. At one atmosphere (760 mm.), water, water vapor, and ice are at equilibrium at 0° C. An increase of pressure to 100 atmospheres lowers the melting point of ice only to −1° C. At 2,000 atmospheres ice melts at −35° C., but at 50,000 atmospheres the solid state exists at nearly twice the temperature of boiling water. There are six different forms of ice, depending on pressure, but none are stable at ordinary atmospheric pressure except the one common form.

The change of volume when water freezes is its most striking property, there being an increase in volume of around 11 per cent. Expansion involved as ice forms produces powerful forces, manifest in damage to plumbing, cracking of pavements, and weathering of rocks. In bodies of water ice rises as it freezes and insulates the water below it, so that continued cold is required before ice forms to excessive depths.

Other physical properties of water, particularly its thermal properties, make it industrially useful. The standard thermal units, the calorie and the British thermal unit (Btu.), are based on water, the former being the quantity of heat required to raise one gram of water at its maximum density through one Centigrade degree, and the latter, one avoirdupois pound of water through one Fahrenheit degree. (The unit, kilocalorie, or 1,000 calories, is more common.)

Approximately 80 calories must be removed from one gram of water at 0° C. to convert it to ice, and about 540 calories are required to convert water at 100° C. to steam. The latter figure is important when condensing steam is employed in domestic and industrial heating systems.

Chemistry.—Since the physical properties of water are dependent upon its chemical structure and composition, some of these will be covered in the discussion of the chemistry of water.

The ancient philosophers included water among the four elements, the other three being earth, air, and fire. The term "element" had a much different meaning at that time, and water represented the properties of cold and fluidity. After the discovery of oxygen and hydrogen, Henry Cavendish (sometime before 1783) caused the two to combine by means of an electric spark, and thus established the composition of water, the reaction being $2H_2 + O_2 = 2H_2O$. It was also observed that two volumes of hydrogen exactly combined with one volume of oxygen. The composition of water was also determined by the action of hydrogen on heated copper oxide, water and metallic copper being formed. The reaction in this case is $CuO + H_2 = Cu + H_2O$.

According to modern theory, water exists in four resonance states, the most common of which is represented by this structure: $\underset{\ddot{H}}{:\ddot{O}:H}$. The angle between the two hydrogen atoms is approximately 105°. Thus, there is a separation of positive and negative charges so that the water molecule is polar or like a little bar magnet, oxygen being the negative end and hydrogen the positive end of the dipole. Water, therefore, has a high dielectric constant, about 81 at 18° C. and is a good solvent for ionic compounds, such as acids, bases, and salts.

Water combines with a great many substances to form hydrates, for example, copper sulphate pentahydrate, $CuSO_4{\cdot}5H_2O$, in which five molecules of water of hydration combine with one molecule of the salt copper sulphate. Other hydrates are Epsom salt, $MgSO_4{\cdot}7H_2O$, and washing soda, $Na_2CO_3{\cdot}10H_2O$. The bond in hydrates is rather easily broken.

Water is held to other substances containing hydrogen by the so-called "hydrogen bond," which involves the attractive forces between the oxygen atom of the water molecule and a hydrogen atom of the other compound. The value of the hydrogen bond is only 5 kilocalories per mole, whereas the value of the covalent bond, in which a pair of electrons are shared between oxygen and another atom, is of the order of 110. If only what are known as van der Waals' forces, or attractions between molecules, were involved, water should have a boiling point near that of neon, whereas the large dipole moment of the water molecules and linkage by hydrogen bonds greatly reduces the vapor pressure of water and limits evaporation. The high specific heat of water is largely the result of hydrogen bonds.

Because of their polar nature and the tendency to form hydrogen bonds, water molecules associate or unite with each other to form a loosely bound aggregate of molecules. Association of water molecules explains the experimental observation that the molecular weight of water in the liquid state is greater than that of water vapor. The tendency to associate increases as the temperature of water decreases. In ice a maximum of four hydrogen bonds are possible, giving an open type of structure with puckered rings of six oxygen atoms with hexagonal symmetry. The identity of each molecule is preserved, with each hydrogen closer to the oxygen of its own molecule than to the oxygen of the other molecules with which it makes hydrogen bonds. When ice melts, it is estimated that 15 per cent of the hydrogen bonds are broken, the fragments being pushed together so that water near the freezing point is more dense than ice.

The extent to which water itself undergoes ionization is very small, being represented by the reaction $H_2O + H_2O = H_3O^+ + OH^-$. The resulting hydronium ion is represented as $\underset{\ddot{H}}{H:\ddot{O}:H^+}$ and the hydroxyl ion as $:\ddot{\underset{..}{O}}:H^-$. The concentrations of each of these ions in pure water is 1×10^{-7} moles per liter. For all practical purposes, pure water is a nonconductor of the electric current. Its conductivity is actually 0.04×10^{-8} reciprocal ohms at 18° C.

Electrolysis of water for the simultaneous production of hydrogen and oxygen is commonly carried out with a solution of a base such as caustic soda, the concentration of which remains constant. The first step is represented as follows: $2H_2O + 2e = H_2 + 2OH^-$ (e = electron). The hydroxyl ion so produced takes up additional electrons to form oxygen and water.

A common reaction involving water is hydrolysis. For example, phosphorus trichloride, PCl_3, reacts with water to form hydrogen chloride, HCl, and phosphorous acid, H_3PO_3. Many carbon compounds undergo hydrolysis, an example being the conversion of acetyl chloride, CH_3COCl, to acetic acid, CH_3COOH, and hydrogen chloride. The salts of weak acids or weak bases undergo hydrolysis when dissolved in water. The products of the reaction are an acid and a base. Sodium acetate, for example, is hydrolyzed to sodium hydroxide and acetic acid. Since sodium hydroxide and acetic acid are not of equal strength, the solution is basic to litmus. Thus, it is because hydrolysis occurs that solutions of some salts are not neutral to litmus.

Water is also formed in many reactions besides the general reaction between hydronium ion and hydroxyl ion in the neutralization of acids by bases. This is particularly true in the chemistry of carbon compounds. An ester is considered as being formed by the splitting out of water between an alcohol and an acid.

Steam reacts with carbon at relatively high temperatures to form a mixture of carbon monoxide and hydrogen known as water gas (q.v.) or synthesis gas.

Heavy Water.—So far water has been considered as being a simple compound of hydrogen and oxygen. For every 5,000 molecules of ordinary water, there is one molecule of what is known to the public as heavy water and to the chemist as deuterium oxide, D_2O. Deuterium is the isotope of hydrogen having an atomic weight of two. Heavy water has a freezing point of 3.82° C. Its boiling point is 101.42° C., and its maximum density is at 11.6° C.

Water Analysis.—Much of what is called water chemistry is the chemistry of substances suspended or dissolved in water. Water analysis involves the determination of these substances and materials. Except for sea water and occasional brine wells, most surface and underground waters are relatively low in dissolved substances. The amounts of dissolved and suspended matter in water are generally measured in terms of parts per million parts of water, or ppm. What are known as mineral waters, which are popularly thought to have medicinal value, rarely ever have more than 5,000 ppm. dissolved matter. Most public water supplies do not exceed 300 ppm. Suspended matter, except for river water in flood stage, is rarely higher than 1,000 ppm., and is often quite low.

Chemical examination of water rarely requires the determination of minor constituents amounting to mere traces. The usual water analysis report includes: suspended matter; total dissolved solids; hydrous silica, alumina, and iron; the cations, sodium, potassium, calcium, and magnesium; and the anions, carbonate, bicarbonate, chloride, and sulphate. In recent years the fluoride ion has become important. Waters with fluoride of the order of 10 ppm. or thereabouts can be very injurious to the teeth of growing children. On the other hand 1 ppm. is regarded by some to be highly beneficial; fluorides are often added to water supplies, since a large proportion of surface and underground water is lacking in this chemical. See also FLUORIDATION.

A sanitary water analysis is primarily dependent on the detection of bacteria. Presence of *Bacterium coli* is indicative of contamination by sewage, and pathogenic bacteria such as *Bacterium typhosum* may be present. Such analyses are supplemented by chemical examination, which is generally limited to biochemical oxygen demand, chlorides in excess of those in uncontaminated supply, and the determination of various forms of combined nitrogen ranging from protein and ammonium compounds to nitrites and nitrates. More or less completely oxidized nitrogen compounds indicate less recent contamination, but are danger signals. Where industrial wastes are a factor, the quantity and nature of toxic metals must be determined. See also WATER SUPPLY—*Treatment and Conditioning*.

Uses.—A limited quantity of water actually enters into chemical reactions in industry in comparison with the vast amount that is unchanged during use. Water consumed by animals and man to sustain life and maintain health also represents a small part of the total. The bulk of water that enters into the national economic picture functions on the basis of its physical properties. Much of this may contain some dissolved and suspended matter without being objectionable.

Drinking water must be very low in dissolved matter, largely because of taste, but also physiological action is an important factor. Least objectionable are such materials as sodium chloride and sodium bicarbonate, while iron, calcium, and magnesium salts are quite undesirable. Organic matter is barred, particularly if derived from sewage or plant wastes.

With the development of high-pressure boilers, the water fed to such equipment must be of a very high degree of purity. Concentration is very rapid and all materials that will cause foaming, corrosion, or scale must be absent. Even small amounts of silicates, which would have been neglected in the past, are now removed.

Alkaline compounds, especially salt and soda, are objectionable in water employed in irrigation, since they remain in the soil on evaporation, and in dry climates are not sufficiently removed by rainfall.

In the chemical process industries there are great variations in the types of water that may be employed. Iron is particularly objectionable in many processes. In the textile and laundry industries where detergents are employed, soap is incompatible with calcium and magnesium salts, but synthetic detergents do not form the same type of sticky precipitates. Naturally a high degree of purity is required in food, pharmaceutical, and fine chemical industries.

Water employed primarily as a coolant does not have to be exceptionally free from dissolved material, and even sea water is used if a certain amount of corrosion can be tolerated or if it is economical to employ highly resistant materials of construction.

See also WATER SUPPLY.

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WATER, Heavy. See ELECTROCHEMICAL INDUSTRIES—*Production of Heavy Water and Deuterium;* NUCLEAR FISSION—*Atomic Piles.*

WATER BABIES, The, subtitled *A Fairy Tale for a Land-Baby,* a story for children by Charles Kingsley (q.v.), published in 1863, with a dedication, "To my youngest son, Grenville Arthur, and to all other good little boys." It is a fairy story heavily charged with didacticism.

Tom, an apprentice chimney sweep, blunders into a wrong room at Harthover Place. The whole household chases him, thinking him a thief. He finally escapes across the moors, plunges into a river, and is changed by the fairies into a water baby. The rest of the story is devoted to his aquatic adventures, first in the river, and then in the ocean.

Kingsley works into the narrative a great deal of his wide knowledge of natural history, but adds still more in the way of moral preaching. The training of the water babies is handled by two fairy godmothers whose functions are sufficiently defined by their names: Mrs. Bedonebyasyoudid and Mrs. Doasyouwouldbedoneby. The underwater world is conceived of as a kind of purgatory in which imperfect spirits are gradually purified by punishments and rewards. Tom's own purification is completed when he makes a toilsome pilgrimage to the Other-end-of-Nowhere to release the soul of his old, cruel master, Mr. Grimes, the chimney sweep.

Kingsley rightly hated cruelty, selfishness, and stupidity, and made his dislike abundantly plain to his child readers. Only their parents, however, are likely to get the full significance of his ironic comments on materialistic scientists, or of his theological overtones. To the modern adult reader (children can probably still take it in their stride) the relentless underscoring of moral preachments is the greatest defect of the book. It is worth noting that *Alice in Wonderland* was published just two years after *The Water Babies.* Lewis Carroll may have got from Kingsley some hints for the character of the Duchess.

DELANCEY FERGUSON.

WATER BEAR. See TARDIGRADA.

WATER BEETLE, the name applied to a number of families of Coleoptera in which the